# COST AND PERFORMANCE REPORT

Pump and Treat of Contaminated Groundwater at the
Former Firestone Facility
Salinas, California

September 1998

EPA

Prepared by:

U.S. Environmental Protection Agency
Office of Solid Waste and Emergency Response
Technology Innovation Office

## SITE INFORMATION

### Identifying Information:

Former Firestone Facility Superfund Site
Salinas, California

**CERCLIS #**: CAD990793887

**ROD Date:** September 30, 1989

### Treatment Application:

**Type of Action:** Remedial

**Period of operation:** February 1986 - November 1992
(Monitoring data collected through July 1993)

**Quantity of groundwater treated during application:** 1.8 billion gallons

### Background

**Historical Activity that Generated Contamination at the Site:** Manufacture of tires

**Corresponding SIC Code:** 3011

**Waste Management Practice That Contributed to Contamination:** Accidental releases of chemicals to soil and groundwater from a RCRA-permitted facility.

**Location:** California

**Operations [1, 2, 4]:**

- The former Firestone facility is located in a suburban industrial area with mixed local land use, both industrial and agricultural. Bordered on the north by a rail line and on the south by a river, the facility operated as a tire manufacturing plant from 1963 until 1980.
- During preclosure investigations of the facility's solid waste management units in 1983, 11 areas were investigated; soil contamination was identified in a materials storage area and in the sludge drying beds. The groundwater investigation found that the levels of several volatile organic compounds (VOCs) exceeded state Primary Drinking Standards. The same investigation identified a plume of VOCs that extended 2.5 miles downgradient.
- On- and off-site groundwater pumping was initiated to reduce further contaminant migration. The evaluation of potential sources of contamination led to the removal of 22 storage tanks and excavation of 5,300 cubic yards of inorganic- and organic-contaminated soils for off-site disposal. The tanks and soil were determined later by the site contractor not to be sources of groundwater contamination.
- After extensive investigation, the principal source of groundwater contamination was believed to be from the use of 1,1,1-trichloroethane (TCA) for maintenance and cleaning of equipment. The site contractor determined that small amounts were released through floor cracks, sumps, and drains. The TCA had degraded to 1,1-dichloroethylene (DCE) and other breakdown products by the time contamination was detected.
- The site was placed on the National Priorities List (NPL) in July 1987.

**Regulatory Context:**

- Remedial actions were underway before the site was placed on the NPL in July 1987. The final ROD was signed on September 30, 1989.
- Site activities are conducted under provisions of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA) §121, and the National Contingency Plan (NCP), 40 CFR 300.

**Groundwater Remedy Selection:**

- The selected remedy for this site was groundwater extraction and treatment via carbon adsorption and air stripping with discharge to a river.

## SITE INFORMATION (CONT.)

### Site Logistics/Contacts

**Site Lead:** PRP

**Oversight:** California Regional Water Quality Control Board (CARWQCB)

**Remedial Project Manager:**
Elizabeth Adams*
U.S. EPA Region 9
75 Hawthorne St.
San Francisco, CA 94105
415-744-2261

**State Contact:**
Dr. Wei Lui*
CARWQCB
Central Coast Region
81 Higuera St., Ste. 200
San Luis Obispo, CA 93401-5427
805-542-4648

**Treatment System Vendor:**
Construction: Monterey Mechanical
Woodward/Clyde
Operations: International Technology Corporation (ITC)

*Indicates Primary Contacts

## MATRIX DESCRIPTION

### Matrix Identification

**Type of Matrix Processed Through the Treatment System:** Groundwater

### Contaminant Characterization [1, 2, 3]

**Primary Contaminant Groups:** Volatile organic compounds

- The contaminants of greatest concern include benzene, 1,1-dichloroethane (1,1-DCA), 1,1,1 trichlorethane (1,1,1-TCA), trichloroethylene (TCE), tetrachloroethylene (PCE), 1,1-dichloroethylene (1,1-DCE), toluene, and xylene.

- 1,1-DCE was selected during the design process as the index compound for the remedial action. The maximum concentration detected on site during the 1983-1984 groundwater investigation was 120 µg/L.

- The plume shown in Figure 1 was based on 1986 sampling events. It was estimated to be 1,300 feet wide and extend 3,400 feet downgradient. In the areas downgradient of the source, the plume was identified in the deeper hydrogeologic zones. High-volume agricultural wells screened in this zone influenced groundwater flow patterns, affecting plume migration.

- Using the surface area in Figure 1, the unit thickness given in Table 1, and an average porosity of 0.3, this report estimates the plume could contain as much as 2.9 billion gallons of contaminated groundwater.

## MATRIX DESCRIPTION (CONT.)

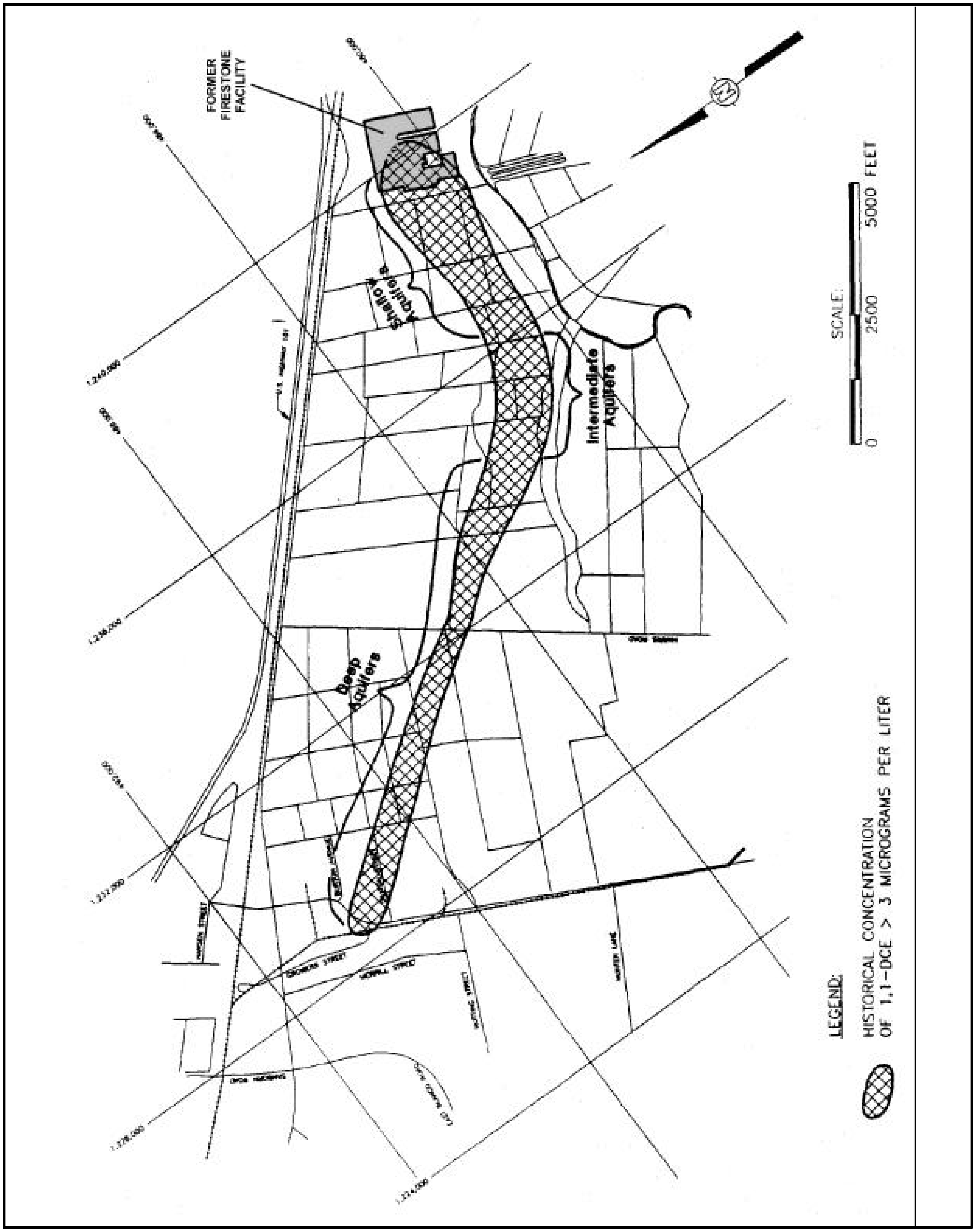


*Figure 1. 1,1-DCE Groundwater Contamination in 1986 [2]*

## MATRIX DESCRIPTION (CONT.)

### Matrix Characteristics Affecting Treatment Costs or Performance [2]

**Hydrogeology:**

Groundwater in the vicinity of the site occurs in three interconnected, aquifer zones, designated the shallow, intermediate, and deep aquifers. The groundwater at this site is contaminated by high levels of nitrate from agricultural activities in the area and is not a suitable drinking water source. The shallow aquifer extends from ground surface to a depth of about 90 feet. The intermediate zone is about 40 feet thick and extends from 100 to 140 feet below ground surface. Locally, the deep aquifer system has four distinct zones at depths of approximately 200, 300, 400, and 500 feet. The various aquifers are separated by locally discontinuous clay or silt layers (aquitards) of varying thicknesses. Where the aquitards are thin or discontinuous, flow and/or dispersion can occur between the overlying and underlying aquifers. The shallow aquifer has limited use because it dries up during drought years. The intermediate aquifer also has limited use because it is very localized and does not yield a large quantity of water. The deep aquifer yields water and is used agriculturally and domestically.

| | | |
|---|---|---|
| Unit 1 | Shallow Aquifer | Composed of permeable sands and gravels enclosed by impermeable silts and clays. This aquifer is underlain by a thin, discontinuous clay horizon. It is of limited use and is dry in drought years. |
| Unit 2 | Intermediate Aquifer | Composed of alluvial channels of sands and underlain by a discontinuous layer of estuarine clay. It is of limited use because of low yield and is highly localized in the area of the site. |
| Unit 3 | Deep Aquifer | Composed of sands and gravel with discontinuous clay aquitards that divide the aquifer into four zones at depths of about 200, 300, 400, and 500 feet. It is extensively developed for agricultural and some domestic uses. |

Tables 1 and 2 present technical aquifer information and well data, respectively.

*Table 1. Technical Aquifer Information*

| Unit Name | Thickness (ft) | Conductivity (ft/day) | Average Velocity (ft/day) | Flow Direction |
|---|---|---|---|---|
| Shallow | 90 | 100 | 2 - 3 | West |
| Intermediate | 10 - 45 | 200 - 1,200 | 2 - 3 | Downward |
| Deep | 200 - 500 | 200 - 1,200 | 3 - 4 | Northwest |

Source: [2]

# TREATMENT SYSTEM DESCRIPTION

**Primary Treatment Technology**

Pump and treat (P&T) with air stripping and carbon adsorption

**Supplemental Treatment Technology**

Oil/water separation

**System Description and Operation [2, 3, 4]**

*Table 2. Extraction Well Data*

| Well Name | Unit Name | Depth (ft) | Yield (gal/day) |
|---|---|---|---|
| S1 - S4 | Shallow | 60 - 72 | 57,600 |
| S5 - S8 | Shallow | 60 - 89 | 72,000 |
| S9 - S11 | Shallow | 52 - 69 | 50,400 |
| S12 - S13 | Shallow | 49 - 57 | 14,400 |
| M1 | Shallow | 98 | 172,800 |
| M2 | Shallow | 82 | 72,000 |
| 5 wells | Intermediate | 90 | 576,000 |
| 5 wells | Off-site Deep | 100 - 150 | 345,000 |

Source: [2]

**System Description [2, 3]**

- The extraction system originally comprised 25 wells installed both on and off site, as listed in Table 2. Fifteen wells were screened in the shallow aquifer and five each were installed in the intermediate and deep aquifers. The extraction system was designed to prevent off-site migration, and the shallow extraction wells were placed along the facility boundary to intercept the plume. In July 1987, five wells were installed off site in the deep aquifer to prevent migration of the plume up into the intermediate zones. In October 1989, five wells were installed off site in the intermediate zone to treat off-site contamination in that zone. The system was designed using a computer model.

- The treatment system consisted of an oil/water separator, an air stripper, and a series of carbon filters. Most of the extracted groundwater was treated in two fixed-bed carbon adsorption filters, operated in series.

- Groundwater from two specific areas was pretreated before being processed through the carbon filters to avoid clogging. Groundwater from the first area, where high levels of oil and grease had been identified, was pretreated using two fixed-bed adsorbers containing Klensorb® adsorbent. The adsorbers were designed to operate in series at a rate of 15 gpm.

- Groundwater from the second area, containing high levels of chlorinated solvents, was pre-treated in an air stripper. The stripper was designed to treat water at a rate of 50 gpm using an air flow of 750 cfm to achieve greater than 98 percent removal.

- Groundwater from all other areas was mixed with the water from the Klensorb® and the air stripping units before passing through the final set of carbon filters at a design rate of 550 gpm.

- Treated groundwater was aerated in effluent tanks prior to discharge to the Salinas River. The aerated water was required to meet minimum dissolved oxygen requirements of the NPDES permit.

# TREATMENT SYSTEM DESCRIPTION (CONT.)

## System Description and Operation (Cont.)

- Groundwater quality is monitored semi-annually in a system of 190 wells, installed in all aquifers both on and off site.

**System Operation [2, 3, 4, 15]**

- Quantity of groundwater pumped from aquifer in gallons:

| Year | Volume Pumped (gal) |
|---|---|
| 1987 | 264,100,000 |
| 1988 | >160,000,000 |
| 1989 | 266,190,000 |
| 1990 | 360,600,000 |
| 1991 | > 182,200,000 |
| 1992 | Not Available |
| **Total** | **1,800,000,000** |

**[Missing data points for six months in 1988, 1991, and all of 1992.]**
Source: [3, 6-14]

- Over the life of this project, the treatment system was 97 percent operational. Downtime was due to regular periodic maintenance and the construction of new wells in 1987.

- The media in the air stripper was not changed over the life of the remedial action. There were at least 15 changeouts of the carbon beds.

- The Remedial Action Plan provided the site manager flexibility to adjust the number of extraction wells pumped and the pumping rates for each well. The site operator reviewed the monitoring data monthly and shifted pumping patterns to optimize contaminant extraction. Examples of the specific operational changes are provided below.

- Over time, pumping was discontinued at the lateral edges of the plume to prevent the plume from migrating transverse to the groundwater flow.

- When on-site pumping began to reduce the flow gradient between the on-site intermediate and deep extraction wells and the on-site shallow extraction wells, the shallow wells were turned off to allow the groundwater flow to increase. Increased groundwater flow carried the remaining contamination to the off-site intermediate wells faster.

- For a two-week period in July 1986, site operators evaluated aquifer response to increased pumping rates. The treatment system flow rate was increased to 950 gpm and the carbon filter system was changed to parallel operations to accommodate the increased flow [2, 4]. As a result of the aquifer response test, the extraction rate was increased.

- In February 1987, the Klensorb® unit was removed from service. From that point, the groundwater was treated directly in the carbon filter system.

- In June 1992, cleanup levels were achieved in all extraction wells, and remediation operations were suspended. Groundwater monitoring has continued since that date.

- As of July 1995, 142 of the 190 extraction and monitoring wells had been decommissioned.

## Operating Parameters Affecting Treatment Cost or Performance

The major operating parameter affecting cost and performance for this technology is the average extraction rate. Table 3 presents the values measured for this and other parameters.

## TREATMENT SYSTEM DESCRIPTION (CONT.)

### Operating Parameters Affecting Treatment Cost or Performance (Cont.)

*Table 3: Operating Parameters*

| Parameter | Value | |
|---|---|---|
| **Average Pump Rate** | **480 gpm** | |
| | **Remedial Goal** | **Performance Standard** |
| 1, 1-DCE | 6 µg/L | 0.21 µg/L |
| Benzene | 0.7 µg/L | 0.7 µg/L |
| 1,1-DCA | 5.0 µg/L | None |
| TCE | 3.2 µg/L | 5 µg/L |
| PCE | 0.7 µg/L | None |
| Toluene | 20 µg/L | 100 µg/L |
| Xylene | 70 µg/L | 620 µg/L |
| Note: Average system pump rate over life of project was an estimated 696,000 gpd, as reported in monthly performance reports. | | |

Source: [1, 4, 6-14]

### Timeline

Table 4 presents a timeline for this remedial project.

*Table 4: Project Timeline*

| Start Date | End Date | Activity |
|---|---|---|
| 10/85 | 2/86 | Multicomponent treatment system constructed |
| 2/86 | 6/86 | System operated at design rate of 550 gpm |
| 7/1/86 | 7/14/86 | System extraction rate increased to 950 gpm to assess effect on vertical groundwater flow |
| 7/15/86 | 10/87 | System modified to operate at 700 gpm |
| 2/87 | --- | Klensorb® unit removed from system; Area 2 wells integrated into remaining system |
| 9/87 | --- | Five deep aquifer extraction wells installed off site |
| 9/89 | --- | Record of Decision issued |
| 9/89 | --- | Five extraction wells installed in intermediate aquifer off site |
| 6/92 | --- | Remedial goals achieved in extraction wells |
| 11/92 | --- | System operations ended for aquifer stability test |
| 11/93 | --- | Seven wells decommissioned |
| | 7/95 | Remedial system decommissioned by state; confirmation sampling continues in 10 wells |

Source: [2, 4, 15]

## TREATMENT SYSTEM PERFORMANCE

### Cleanup Goals/Standards [1]

- The remedial goals shown in Table 3 were based on chemical-specific applicable or relevant and appropriate requirements (ARARs), that include Maximum Contaminant Levels (MCLs) and health-based restrictions such as carcinogenic risk levels of less than $10^{-6}$ and a Hazard Index of 1. These goals were to be achieved throughout the affected aquifers [1].

### Additional Information on Goals [4]

- The initial remedial goal for 1,1-DCE was 0.2 µg/L, based on state drinking water standards. In June 1986, the California Department of Health Services (DHS) revised the state drinking water action level for 1,1-DCE to 6 µg/L. This level became the final remedial goal.

### Treatment Performance Goals [2]

- The primary goal of the treatment system was to reduce levels of 1,1-DCE in the influent to below NPDES standards, listed in Table 3.
- The secondary goal of the system was to prevent the migration of contaminants into the adjoining property to the northwest.

### Performance Data Assessment [1, 5-14]

*Total VOCs include 1,1-DCA, 1,1,1-TCA, TCE, PCE, and 1,1-DCE for the purposes of this section.*

- Figure 2 illustrates the decline of average 1,1-DCE contaminant concentrations in groundwater over time. As shown in this figure, the average level of 1,1-DCE (the index contaminant) in the groundwater dropped by half in the first year, from 120 µg/L to an average of 61 µg/L. The average concentration dropped by half again in the following year. The average concentrations for 1994 and 1995 were 4.8 and 6.0, respectively. Average concentrations in monitoring wells were provided by the system operator.
- There were no reported exceedences of the NPDES limits over the life of the remedial action [5-13].
- Contaminants were detected in downgradient monitoring wells during a 1986 sampling event, indicating that full containment had not been achieved. This led to the installation of five off-site wells in the deep aquifer in 1987. No further migration of contaminants has been noted in subsequent sampling events. Therefore, it appears that the contaminant plume was contained by 1987 [1, 4].
- Figure 3 shows that from 1986 to 1992, 496 pounds of total VOCs were removed from the groundwater. The shape of the mass removed curve indicates a continuous reduction in removal efficiency over the life of the operating system.
- The mass flux rate declined steadily from 77 lbs during the first half of 1986 to 0.7 lbs in the last six months of operations. The sharpest decline in the removal rate was noted in the first 36 months during which the removal rate dropped 84 percent from 77 lbs/6-month period to 18.7 lbs/6-month period. Over the next four years, the removal rate declined to 0.7 lbs/6-month period [6-14].

### Performance Data Completeness

- NPDES monitoring reports, containing treatment system flow volumes, influent concentrations, and contaminant mass removed, are available on a semi-annual basis from June 1986 to July 1993 [5-13].
- Groundwater monitoring data are available in monthly reports from February 1986 to July 1993.

# TREATMENT SYSTEM PERFORMANCE (CONT.)

## Performance Data Completeness (Cont.)

- Contaminant removal data were supplied by the system operator for each six-month period from June 1986 to November 1992 [4].
- The data used in Figure 2 are the highest concentrations found in any well over a 12-month period [4].
- Annual concentrations in monitoring wells were provided by the system operator for 1986, 1987, 1988, and 1993.

## Performance Data Quality

- The QA/QC program used throughout the remedial action met the EPA and the State of California requirements.  All monitoring was performed using EPA-approved methods, and the site engineer did not note any exceptions to the QA/QC protocols.

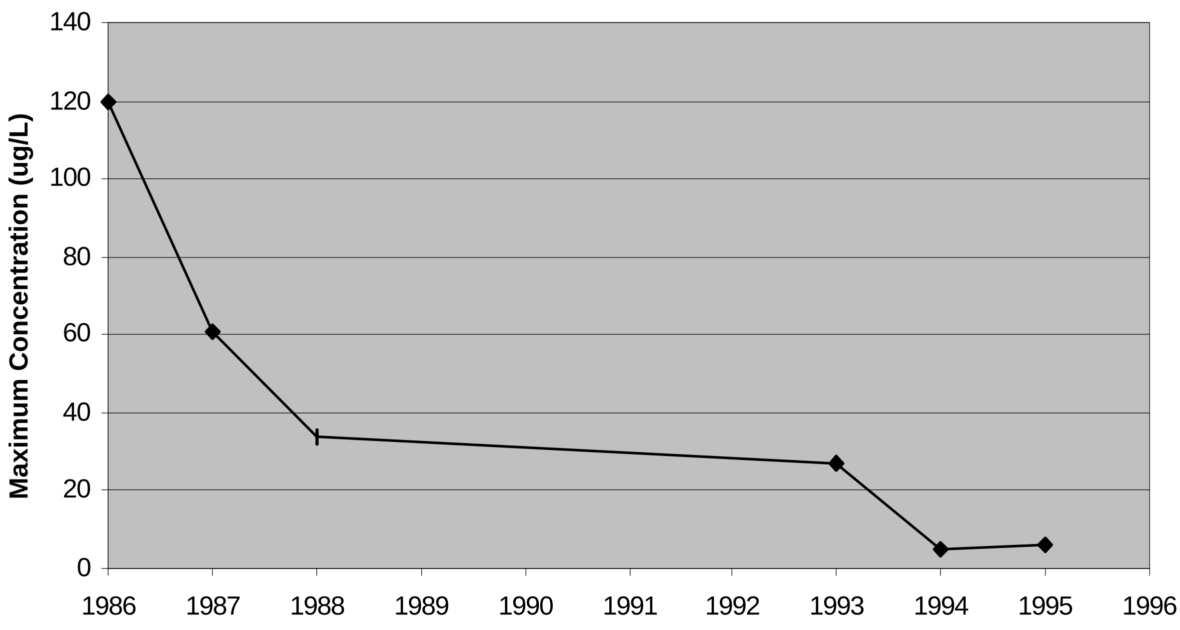


*Figure 2.  Groundwater 1,1-DCE Concentrations, 1986 - 1992 [4]*

## TREATMENT SYSTEM PERFORMANCE (CONT.)

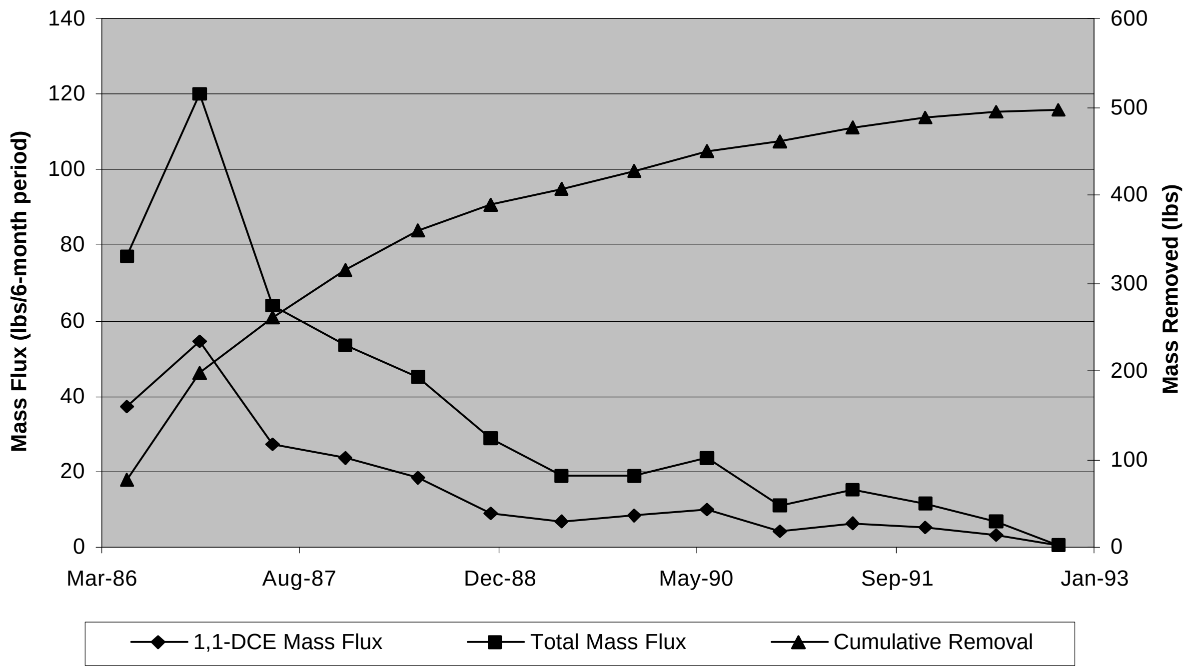


*Figure 3. Mass Flux Rate and Cumulative Contaminant Removal, 1986 - 1992* [4]

## TREATMENT SYSTEM COST

### Procurement Process

- From 1983 to 1986, Woodward-Clyde constructed and operated the remedial treatment system. In August 1986, International Technology Corp. took over the operations and maintenance of the system.

### Cost Analysis

- All costs for design, construction, and operation of the treatment system at this site were borne by the PRPs.

### Capital Costs [4, 5]

| | |
|---|---|
| Remedial Construction | |
| Extraction Wells Treatment | $749,344 |
| System/Wells/Caps | $3,314,899 |
| Site Restoration | $69,300 |
| **Total Construction** | **$4,133,543** |

### Operating Costs [4, 5]

| | |
|---|---|
| Plant Operations | $3,056,430 |
| Monitoring/Analysis/Data Management | $3,524,622 |
| Project Management | $2,170,218 |
| **Total Operating Expenses** | **$8,751,270** |

### Other Costs [5]

| | |
|---|---|
| Remedial Design | $3,030,175 |
| Miscellaneous Cost | $9,176,300 |

Note: UST removal, lagoon closure, soil removal and disposal, and other costs unrelated to groundwater cleanup are not included here.

## TREATMENT SYSTEM COST (CONT.)

**Cost Data Quality**

Actual capital and operations and maintenance cost data were available from the PRPs.

## OBSERVATIONS AND LESSONS LEARNED

- The cleanup standards were met at this site within approximately seven years.
- There were no changes in system construction or operation that significantly changed the expected cost of remediation.
- Actual costs for the P&T treatment application were $4.1 million in capital costs and $8.8 million in operating and maintenance costs, which corresponds to $26,000 per pound of contaminants removed and $7 per thousand gallons of groundwater pumped.
- The site operators frequently adjusted the extraction system to control contaminant removal from the aquifers [4]. The effect of this flexible operation was to maximize the removal of contaminants from the groundwater and maintain the highest possible level of concentrations in the influent stream. This operational strategy was key to avoiding the asymptotic decline in contaminant removal that other P&T systems have experienced.
- Often, concentrations of 1,1-DCA were higher at the sample point before the second carbon bed than at the point directly before the first bed. This pattern suggests that 1,1-DCE was being preferentially adsorbed in the first bed, displacing previously adsorbed 1,1-DCA [6].

## REFERENCES


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4. Various communications with Corporation. July 2 to August 15, 1997.
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8. Semi-Annual NPDES Report for January - June 1988. International Technology Corporation, July 28, 1988.
9. Semi-Annual NPDES Report for January - June 1989. International Technology Corporation, July 28, 1989.
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13. Semi-Annual NPDES Report for January - June 1991. International Technology Corporation, July 30, 1991.
14. Semi-Annual NPDES Report for July - December 1993. International Technology Corporation, January 28, 1994.
15. Letter to CADTSC. International Technology Corporation, November 1993.


### Analysis Preparation

This case study was prepared for the U.S. Environmental Protection Agency's Office of Solid Waste and Emergency Response, Technology Innovation Office. Assistance was provided by Eastern Research Group, Inc. and Tetra Tech EM, Inc. under EPA Contract No. 68-W4-0004.

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